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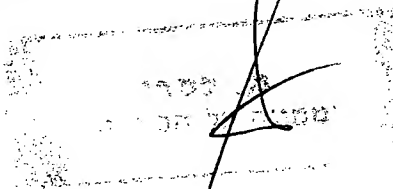
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Application For Patent

מספר: Number	123925
תאריך: Date	02-04-1998
הו קד/נדחה: Ante/Post-dated	

אני, (שם המבקש, מענו ולגבי גוף מאוגדת מקום התאגדותו)  
I, (Name and address of applicant, and in case of body corporate-place of incorporation)

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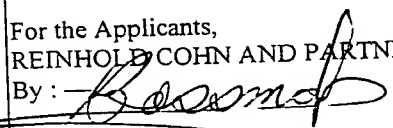
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(English)

Assay for the diagnosis of schizophrenia based on a new peptide

Hereby apply for a patent to be granted to me in respect thereof.

מבקש בזאת כי ינתן לי עליה פטנט

<p>בקשת חלוקה * Application of Division</p> <p>מבקשת פטנט from application</p> <p>No. _____ מס' _____</p> <p>Dated _____ מיום _____</p>		<p>בקשת פטנט מוסף * Appl. for Patent of Addition</p> <p>לבקשה/לפטנט to Patent/Appl.</p> <p>No. _____ מס' _____</p> <p>dated _____ מיום _____</p>		<p>דרישת דין קדימה * Priority Claim</p>		
<p>P.O.A.: Special To be filed</p>		<p>* יפוי כח : מיוחד עוד יוגש</p>		מספר/סימן Number/Mark	תאריך Date	מדינת האגוד Convention Country
<p>המען למסירת מסמכים בישראל Address for Service in Israel</p> <p>REINHOLD COHN AND PARTNERS Patent Attorneys P.O.B. 4060, Tel-Aviv</p>				<p>C. 108514</p>		
<p>חתימת המבקש Signature of Applicant</p> <p>For the Applicants, REINHOLD COHN AND PARTNERS By : </p>				<p>היום 2 בחודש April שנת 1998 This of the year</p>		

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מבחן לגלוי סכיזופרניה המבוסס על פפטיד חדש

Assay for the diagnosis of schizophrenia based on a new peptide

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ידע חברה למחקר ופתוח בע"מ

הממציאים:  
מאיר שיניצקי  
מיכאל דקמן

C.108514

## ASSAY FOR THE DIAGNOSIS OF SCHIZOPHRENIA BASED ON A NEW PEPTIDE

### FIELD OF THE INVENTION

The present invention is generally in the field of assays for the diagnosis of mental disorders. More specifically, the present invention provides an assay for the diagnosis of schizophrenia.

5

### PRIOR ART

The following is a list of prior art publications referred to in the present specification.

- 10 1. Carpenter, W.T., and Buchanan, R.W., *Review, N. Engl. J. Med.*, 330681-690, 1994.
2. Knight, J.G., *Find. Exp. Clin. Pharmacol.*, 6:395-408, 1984.
- 15 3. De Lisi, L.E., and Crow, T.J., *Psychiatr. Clin. North Am.*, 9:115-132, 1987.
4. Ganguli, R., Rabin, B.S., Kelly, R.H., Lyte, M. and Ragu, U., *Ann. N.Y. Acad. Sci.*, 496:676-690, 1987.
- 20 5. Shinitzky, M., Deckmann, M., Kessler, A., Sirota, P., Rabbs, A. and Elizur, A., *An. N.Y. Acad. Sci.*, 621:205-217, 1991.
- 25 6. Deckmann, M., Shinitzky, M., Leykin, I., Cheng, D., Guy, J., Avnon, M., Salganik, I., Amiri, Z., Schlossberg, A., Leibur, E., and Rafael, C., *The Italian J. Psychiatr. Behav. Sci.*, 6:29-34, 1996.
7. PCT Patent Application Publication Number WO 95/23970.

The acknowledgement herein of the above art should not be construed as an indication that this art is in any way relevant to the patentability of the invention as defined in the appended claims.

The above publications will be acknowledged in the following  
5 by indicating their number from the above list.

## BACKGROUND OF THE INVENTION

Schizophrenia is a syndrome which encompasses a variety of mental symptoms like auditory hallucinations, paranoia, delusions, catatonia,  
10 bizarre behavior or emotional withdrawal. Schizophrenia affects about 1% of the total population and its economical as well as social burden on society are enormous. The onset of the disease occurs at an early age and thus patients typically need life-long medical and psychiatric supervision. Schizophrenia is, therefore, rated as one of the most costly diseases in the industrial world<sup>1</sup>.

15 There are various known risk factors associated with schizophrenia such as genetic predisposition, birth during winter and complications during pregnancy and birth. Viral infections and subsequent autoimmune reactions have also been proposed as possible causative factors<sup>2-4</sup>. The involvement of autoantibodies against platelets in  
20 schizophrenic patients was also shown as elevated levels of autoantibodies were detected in schizophrenic and demented patients as compared to control subjects, bipolar, depressed, personality disordered or schizoeffective patients<sup>5-6</sup>. Western Blot analysis revealed a pattern of platelet antigens recognized by autoantibodies obtained from schizophrenic patients which  
25 differed from that recognized by autoantibodies obtained from patients suffering from autoimmune thrombocytopenia and dementia<sup>7</sup>. The antigen bound specifically by autoantibodies obtained from schizophrenic patients has been characterized by its molecular weight.

## SUMMARY OF THE INVENTION

In accordance with the invention, several proteins which bind autoantibodies that are found in elevated levels in body fluids of schizophrenic patients have been identified. The antibodies which these  
5 proteins bind are typically platelet associated autoantibodies (PAA). Such autoantibodies obtained from schizophrenic patients (hereinafter "*schizophrenic derived antibodies - SDA*") were shown to bind the above antigens while autoantibodies obtained from control non-schizophrenic individuals (hereinafter "*non-schizophrenic derived antibodies - NSDA*") did  
10 not.

The proteins which were shown to be capable of binding SDA were identified and further characterized by chemical and enzymatic methods. Some of the identified immuno-reactive proteins are known proteins such as glyceraldehyde-3-phosphate dehydrogenase (G3PD), enolase, keratin,  
15 hepatocyte growth factor, extracellular calcium sensing receptor and several more. By digesting the rabbit protein enolase, an immunologically active peptide was revealed which had a high binding activity to SDAs.

The revealed peptide, being the immunologically active epitope of the enolase protein, comprised twenty eight amino acids of the following  
20 sequence:

SGETEDTFIADLVVGLCTGQIKTGAPCR (Seq. ID No. 1)

On the basis of the revealed peptide, additional peptides were synthesized and highly active ones (i.e. such which had a high binding activity to SDAs as compared to a very low binding activity to NSDA or which do not  
25 bind NSDA at all) were identified. Moreover, the synthesized active peptides were capable of differentiating for the first time between plasma samples obtained from schizophrenic patients and plasma samples obtained from control non-schizophrenic individuals.

Further analysis of one of the synthesized highly active peptides  
30 (Seq. ID No. 2) showed that this peptide forms a ring via two cysteins and a

dimer via the remaining free cystein. The peptide in this form is most active in its ability to bind SDA.

As described below, the antigenic epitope of the synthetic highly active peptides of the invention seems to be a three dimensional spatial  
5    eptiope.

The present invention thus provides a peptide which binds antibodies that are found in elevated levels in body fluids of schizophrenic patients.

The invention further provides a peptide capable of binding  
10    antibodies that are found in elevated levels in body fluids of schizophrenic patients, wherein the peptide binds antibodies that are capable of specific binding to a peptide having the following amino acid sequence: LVVGLCTCQIKTGAPAC (I.D. No. 2). Several non-limiting examples of such peptides are the following:

- 15       iii.    IADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 3)
- iv.    ADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 4)
- v.     DLVVGLCTGQIKTGAPCR (Seq. I.D. No. 5)
- vi.    LVVGLCTGQIKTGAPCR (Seq. I.D. No. 6)
- vii.   LVVGLCTGQIKTGAPCR (Seq. I.D. No. 7)
- 20       viii.   LVVGLCTPQIKTGAPCR (Seq. I.D. No. 8)

The invention also provides a peptide which is capable of binding antibodies that are found in elevated levels in body fluids of schizophrenic patients, such peptides capable of binding antibodies which do not bind to peptides selected from the group consisting of :

- 25       i.     SGETEDTFIADLVVGLCTGQ (Seq. I.D. No. 9)
- ii.    VVGLCTGQIKTGAPCR (Seq. I.D. No. 10)
- iii.   CTGQIKTGAPCR (Seq. I.D. No. 11)
- iv.    LVVGLCTGQIKTGAPC (Seq. ID. No. 12)
- v.     LVVGLCTGQIKTGAP (Seq. ID No. 13)
- 30       vi.    LVVGLCTGQIKTGAPAC (Seq. ID No. 14)

The invention also provides a peptide capable of binding to antibodies that are found in elevated levels in body fluids of schizophrenic patients comprising an amino acid sequence selected from the group, consisting of:

- 5        i.     SGETEDTFIADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 1)
- ii.    LVVGLCTCQIKTGPAC (Seq. I.D. No. 2)
- iii.   IADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 3)
- iv.    ADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 4)
- v.     DLVVGLCTGQIKTGAPCR (Seq. I.D. No. 5)
- 10       vi.    LVVGLCTGQIKTGAPCR (Seq. I.D. No. 6)
- vii.   LVVGLCTGQIKTGPACR (Seq. I.D. No. 7)
- viii.  LVVGLCTPQIKTGPACR (Seq. I.D. No. 8)

By a preferred embodiment the invention provides a peptide capable of binding antibodies that are found in elevated levels in body fluids of schizophrenic patients selected from the group consisting of:

- 15       i.     SGETEDTFIADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 1)
- ii.    LVVGLCTCQIKTGPAC (Seq. I.D. No. 2)
- iii.   IADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 3)
- iv.    ADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 4)
- 20       v.     DLVVGLCTGQIKTGAPCR (Seq. I.D. No. 5)
- vi.    LVVGLCTGQIKTGAPCR (Seq. I.D. No. 6)
- vii.   LVVGLCTGQIKTGPACR (Seq. I.D. No. 7)
- viii.  LVVGLCTPQIKTGPACR (Seq. I.D. No. 8)

The letters used above (and hereinafter) to denote specific a.a. are in accordance with the one-letter amino acid (a.a.) symbols recommended by the IUPAC-IUB Biochemical Nomenclature Commission.

Without being bound by theory, on the basis of the results obtained in accordance with the invention, it has become clear that the structure of the antigenic epitope of the peptides to which SDAs are capable of binding at a substantially higher degree as compared to NSDAs is a



three-dimensional epitope. By using a computerized program based on minimal energy calculations, the antigenic epitope of a peptide in accordance with the invention is predicted as being a cyclic structure comprising a hydrophobic core and an extension having about two positive charges. The  
5 positive charged extensions may be positioned in one of many possible spatial orientations.

The binding activity of the peptide of the invention to various antibodies may be determined by any of the methods known *per se* such as ELISA or Western Blotting. For example, a tested peptide may be analyzed  
10 for its binding activity to antibodies by subjecting it to polyacrylamide gel electrophoresis, blotting it onto PVDS membranes which are then reacted with SDA and compared to their reaction with NSDA.

The extent of binding of the peptides of the invention to PAA can be determined by using any detection system known in the art such as  
15 antibodies against human immunoglobulin or fragments thereof linked to a detectable marker. The marker may be a radioactive group, a fluorescent group, an enzyme capable of catalyzing a reaction yielding a detectable product, a biotin group capable of being detected by avidin, etc.

By a preferred embodiment of this aspect, the peptides of the  
20 invention are bound onto a solid support such as e.g. a PVDF membrane, reacted with the tested sample and the level of binding of the PAAs in the sample is determined using an anti-human Fc antibody conjugated to a detectable marker.

In accordance with a particular embodiment, the determination  
25 of the level of autoantibodies bound to a tested peptide is determined by using anti-human Fc conjugated to horseradish peroxidase (SIGMA) and Fast-DAB™ (SIGMA) or 4-Chloro-naphthol (SIGMA) as the color reagent.

In order for the binding of the tested peptide in accordance with the invention to SDA to be considered "*substantially higher*" than its binding  
30 to NSDA, the level of binding to SDA should be statistically significantly

higher than its binding to NSDA as determined by any of the statistical methods known in the art (e.g. Students' t-Test) which are used in connection with results obtained by the experimental methods mentioned above.

5       Analogues of all the above peptides also form an aspect of the present invention. As will be appreciated by any person versed in the art, the amino acid sequence of the peptides of the invention may be altered, for example by addition, replacement or deletion of one or more amino acids without substantially altering the binding capacity of the peptide to SDAs. Thus for example the leucine positioned in the first position of the amino acid  
10       sequence of a peptide of the invention may be substituted by the amino acid glycine or valine which belong to the same family of amino acids without altering the binding activity of the peptide. A person versed in the art will have no difficulty in determining by which amino acid each of the amino acids of the peptide may be replaced in accordance with the known grouping  
15       of amino acids into families as may be found, for example, in *Molecular Biology of the Cell* Editors Alberts B. *et al.*, Garland Publishing, Inc., New York and London, 2nd Edition, 1989, pages 54-55.

      Analogues which fall under the scope of the peptides of the present invention are such which have substantially the same level of binding  
20       activity to SDAs, as the peptides i.e. have a higher level of binding to SDAs as compared to NSDAs as determined by any of the methods known in the art such as for example that described in Example 1 below.

      The peptide of the invention may be obtained by enzymatic digestion (e.g. using Clostrapain) or chemical (CNBr) digestion of a longer  
25       protein. In such a case, the resulting peptides are separated by methods known in the art such as by RP-HPLC and the separate peptides may then be used for sequencing (e.g. by Eurosequence b.v. (Nijenborgh 4; 9749 Gronigen; The Netherlands)) and analyzed for their binding capability to SDAs as described above.

Peptides in accordance with the invention may also be synthesized by methods known in the art such as on Abimed 522 at a 10  $\mu$ mol scale by Eurosequence b.v. (see detailed explanation in the examples below). The binding activity of the newly synthesized peptides will be determined  
5 using any of the assays mentioned above.

The peptides of the invention are capable of differentiating between a sample obtained from an individual suffering from schizophrenia and a sample obtained from a non-schizophrenic individual and are therefore useful in the diagnosis of schizophrenia in an individual. Thus, by another of  
10 its aspects, the present invention provides a peptide for use in the diagnosis of schizophrenia in an individual, said peptide capable of binding antibodies that are found in elevated levels in body fluids of schizophrenic patients.

The sample of the individual to be tested is typically a PAA containing fraction of a blood sample comprising platelets. However, in  
15 accordance with the present invention it has become possible for the first time to determine the probability of existence of schizophrenia in a plasma sample taken from tested individuals without the need to first isolate PAA from the sample. Thus, in accordance with the invention, the sample of an individual to be tested may either be a plasma sample or a PAA containing fraction  
20 obtained therefrom by any of the methods known in the art (e.g. by obtaining a platelet-rich plasma (PRP) and isolating PAA therefrom).

Since the peptides of the invention are capable of binding to a different extent to platelet derived autoantibodies in a sample obtained from a schizophrenic patient as compared to a sample obtained from a control  
25 non-schizophrenic individual, the peptides may be used in an assay for diagnosis of schizophrenia in an individual. Therefore, the present invention by an additional aspect provides an assay for the diagnosis of schizophrenia in an individual, comprising the following steps:

- (a) obtaining a sample from said individual being a blood sample, a platelet-containing fraction thereof, or a fraction containing platelet-associated antibodies (PAA) shed from the platelets;
- 5 (b) contacting said sample with a peptide capable of binding to antibodies that are found in elevated levels in body fluids of schizophrenic patients.
- (c) determining the level of binding of said peptide to said sample, a level higher than the binding level of said peptide to a sample from non-schizophrenic individuals indicating that said individual has a
- 10 high likelihood of having schizophrenia.

By a further embodiment the peptide of step (b) above is a peptide which binds antibodies that are capable of specific binding to a peptide having the amino acid sequence of Seq. ID. No. 2. By another embodiment the peptide in step (b) above comprises an a.a. sequence selected

15 from the group consisting of:

- i. SGETEDTFIADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 1)
- ii. LVVGLCTCQIKTGAC (Seq. I.D. No. 2)
- iii. IADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 3)
- iv. ADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 4)
- 20 v. DLVVGLCTGQIKTGAPCR (Seq. I.D. No. 5)
- vi. LVVGLCTGQIKTGAPCR (Seq. I.D. No. 6)
- vii. LVVGLCTGQIKTGAC (Seq. I.D. No. 7)
- viii. LVVGLCTPQIKTGAC (Seq. I.D. No. 8)

By a preferred embodiment, the peptide in step (b) is a peptide

25 selected from the group consisting of:

- i. SGETEDTFIADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 1)
- ii. LVVGLCTCQIKTGAC (Seq. I.D. No. 2)
- iii. IADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 3)
- iv. ADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 4)
- 30 v. DLVVGLCTGQIKTGAPCR (Seq. I.D. No. 5)

vi. LVVGLCTGQIKTGAPCR (Seq. I.D. No. 6)

vii. LVVGLCTGQIKTGACR (Seq. I.D. No. 7)

The present invention also provides a kit useful in the above assay. The kit of the invention comprises a support comprising one or more peptides of the invention immobilized onto it and an anti-human immunoglobulin antibody or fragment thereof. The anti-HIG antibody may be conjugated to a detectable marker or alternatively, the kit may also comprise a second type of antibodies directed against said first antibodies, wherein the second antibodies are conjugated to a detectable marker. The kit will also  
10 comprise various reagents required for carrying out the assay as well as instructions for use.

The invention will now be illustrated in the following non-limiting description of specific embodiments and accompanying drawings.

15

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graphical representation showing binding activity of the Peptide 14 having Seq. I.D. No. 2 to PAAs prepared from samples obtained from schizophrenic patients (Fig. 1A) and non-schizophrenic individuals  
20 (Fig. 1B). The peptide having Seq. I.D. No. 9 was used as a negative control.

Fig. 2 is a graphical representation showing binding activity of peptide 14 (Seq. I.D. No. 2) to plasma samples obtained from schizophrenic patients (Fig. 2A) and non-schizophrenic individuals (Fig. 2B). The peptide having Seq. I.D. No. 9 was used as a negative control.

25 Fig. 3 is a graphical representation showing a schematically predicted three-dimensional structure of the antigenic epitope of the peptides of the invention as determined by a computerized program based on minimal energy calculations.

## EXAMPLES

### Materials and Methods

#### 1. Platelets and anti-platelet autoantibodies

5 Venous blood (20 ml) was drawn with heparin as anticoagulant from patients and control subjects. Platelet rich plasma (PRP) was obtained by centrifugation (100 g for 20 mins) at room temperature. Plasma free platelets were obtained by washing them three times with phosphate buffered saline (PBS) supplemented with 10 ml mM EDTA as anticoagulant (4000 g; 15 mins; 4°C). For the isolation of anti-platelet antibodies, the platelets were incubated with 0.1 M glycine/10 mM EDTA, pH 2.8, for 10 min. at room temperature and then centrifuged (4000 g; 15 min; 4°C). The supernatant containing the anti-platelet antibodies, was neutralized with saturated Na<sub>2</sub>PO<sub>4</sub> solution and stored at -20 until use.

#### 2. Preparative isoelectric focusing

15 Platelet concentrates of blood group 0 were purchased from a local blood bank and washed three to five times with PBS/10 mM EDTA (4000 g; 15 min; 4°C) until the supernatant was free of plasma. The platelets (about 20 concentrates) were first solubilized with 20 ml 0.5% Triton X-100/0.5% NP40 in water for 15 min. at room temperature under gentle shaking. The suspension was centrifuged (10000 g, 15 min. 4°C), the supernatant removed and the pellet two more times extracted with 0.1% Triton X-100 in water. The three supernatants were combined and Ampholyte™ 3/10 (BioRad) was added to a final concentration of 1%. This solution was loaded into the ROTOFOR™ chamber (capacity 60 ml) and the preparative isoelectric focusing was then performed according to the instruction manual of the manufacturer (BioRad). Typically, the focusing was finished after 4.5 h (10°C; 10 Watt constant power). Twenty fractions were harvested and the pH of

20

25

30

the fractions determined (pH gradient 1.5-12). The fractions were stored at -20°C until further use.

---

3. Identification of immuno-reactive fractions

5           The fractions were analyzed for immuno-reactivity by polyacrylamide (10%) gel electrophoresis, blotting the proteins onto PVDF membranes and probing the membrane with 1 ml auto-antibodies in 50 ml incubation buffer. Anti-human Fc conjugated to horseradish peroxidase (goat) from SIGMA (1:500 dilution) and Fast-DAB™ (SIGMA) or 4-Chloro-naphthol (SIGMA) were used as color reagent in 10           order to detect bound human anti-platelet antibodies. Immuno-reactivity was observed in the fractions with a pH ranging from 6.0 to 10.0.

4. Preparative polyacrylamide (8%) gel electrophoresis

15           The immuno-reactive fractions (pH 6-10) were combined and separated according to molecular weight under reducing conditions by preparative SDS polyacrylamide gel (8% and 8 cm height) in a PrepCell from BioRad according to the instruction manual of the manufacturer. Fractions (n=400) of 1.5 ml were collected: every tenth fraction was 20           analyzed by SDS gel electrophoresis followed by silver staining to determine the molecular weight distribution in the 400 fractions.

5. Identification of immuno-reactive fractions

25           Every fifth fraction (0.1 ml) was dot blotted onto PVDF membranes using the DotBlot device (96 wells) from BioRad. Immuno-reactive fractions were then detected as described above (1.3)

6. Identification of immuno-reactive proteins

30           As described previously, a variety of immuno-reactive proteins were identified. Priority for sequencing was given to proteins with a

high ratio of reactivity to protein amount. Preparation of sample was typically done in the following way: The fractions (+/- 10) around a positive fraction were re-analyzed as described above under 1.5. The positive fractions were combined, lyophilized, re-separated on an analytical (0.75 mm) SDS polyacrylamide (10%) gel and stained with Coomassie Blue. The band was excised and sent to Eurosequence b.v. (enzymatic digestion, RP-HPLC separation of peptides followed by amino acid sequencing).

5

7. Identification of immuno-reactive epitope

Of the identified proteins, two were found to be commercially available:

- a) Glyceraldehyde-6-phosphate dehydrogenase (G6PD)
- b) Enolase

15

About 10 mg protein was digested either enzymatically (Clostrapain) or chemically (CNBr) and the resulting peptides were separated by RP-HPLC. Aliquot (20%) of all fractions were sent by Eurosequence b.v. to the Main Inventor for analysis of immuno-reactivity as described under 1.5. Only the enzymatic digest of the Enolase resulted in an active fragment which was subsequently sequenced by Eurosequence b.v.

20

8. Peptide synthesis

Various peptides were synthesized on Abimed 522 at a 10 micromol scale by Eurosequence b.v. Peptides were routinely dissolved in 1 ml water/DMF/DMSO (1:1:1;v/v/v). Peptides were line-blotted onto PVDF membranes and tested for immuno-reactivity as described above.

25



**EXAMPLE 1: Identification of immuno-reactive proteins**

---

The following proteins have been identified as such capable of binding autoantibodies present in high levels in schizophrenic patients at a high level as determined by the assay described in 1.3 above:

5

**Protein:**

Glyceraldehyde-6-phosphate dehydrogenase

Enolase

Keratin

10

Hepatocyte growth factor

Extracellular calcium sensing receptor

15

The above identified proteins were tested for their binding capability to plasma samples obtained from schizophrenic patients and to plasma samples obtained from control non-schizophrenic patients. The results showed that it was not possible to use the above proteins to discriminate between a plasma sample obtained from a schizophrenic patient and that obtained from a non-schizophrenic individual, i.e. the binding results were not conclusive.

20

The binding activity of the above two enzymes was then tested by reacting them with SDAs (prepared from samples obtained from schizophrenic patients) and to NSDA (prepared from control non-schizophrenic individuals). As seen in Table 1 below, in this case binding of the proteins to SDAs was substantially higher than their binding to NSDAs expressed by the number of samples that reacted positively with each of the enzymes.

25

Table 1

Reactivity of proteins to SDAs and NSDAs

Enzyme	Patients (n=8)	Controls (n=8)
	Positive	Positive
<b>G-3-P-Dehydrogenase</b>		
from human	7/8	1/8
from pig	8/8	1/8
from chicken	7/8	2/8
from yeast	6/8	1/8
from bacillus subtilis	1/8	2/8
<b>Enolase</b>		
from Rabbit	7/8	1/8

The above results showed that the proteins obtained in accordance with the invention may be useful in the diagnosis of schizophrenia in a tested individual but require that the sample obtained and tested from the individual will comprise of prepared platelet-derived autoantibodies. The enzymes are not suitable for detecting schizophrenia directly in a plasma sample.

**EXAMPLE 2:** Identification of the epitope in the digested proteins capable of specific binding to SDAs:

Chemical (CNBr) and enzymatic digestions (Clostrapain) of human G-3-P-Dehydrogenase and rabbit Enolase were used to identify the epitope. Only the enzymatic digest of the Enolase revealed one peptide which was immunologically active (amino acids 372-399; The peptide having Seq. I.D. No. 1 in the following Table 2), i.e. was

capable of binding SDAs to a higher extent and its capability of binding to NSDAs.

5      Based on the sequence of the epitope identified in the digested proteins, a number of peptides were synthesized by the method described in 1.8 above. The synthesized peptides were then evaluated for their binding activity to SDAs as compared to NSDAs as described above.

10      As seen in Table 2 below, several of the synthesized peptides showed a substantially higher binding activity to SDAs as compared to their binding to NSDAs (indicated as YES in the table) while others showed no significant differences in their binding to samples from schizophrenic and non-schizophrenic individuals (designed as **no** in the table).

Table 2

Peptide	Seq. I.D.No.	Activity
SGETEDTFIADLVVGLCTGQIKTGAPCR (28aa)	1	YES
LVVGLCTCQUKTGPAC (17aa)	2	YES
IADLVVGLCTGQIKTGAPCR (20aa)	3	YES
ADLVVGLCTGQIKTGAPCR (19aa)	4	YES
DLVVGLCTGQIKTGAPCR (18aa)	5	YES
LVVGLCTGQIKTGAPCR (17aa)	6	YES
LVVGLCTGQUKTGPACR (17aa)	7	YES
LVVGLCTPQUKTGPACR (17aa)	8	YES
SGETEDTFIADLVVGLCTGQ (20aa)	9	No
VVGLCTGQIKTGAPCR (16aa)	10	No
CTGQIKTGAPCR (12aa)	11	No
LVVGLCTGQIKTGAPC (16aa)	12	No
LVVGLCTGQIKTGAP (15aa)	13	No
LVVGLCTGQIKTGAPAC (16aa)	14	No

Of the synthesized peptides, Peptide Seq. I.D. No. 2 was most capable of binding to antibodies found in high levels in schizophrenic patients.

**EXAMPLE 3: Characterization of Peptide Seq. I.D. No. 2**

5                   Laser desorption mass spectroscopy of Peptide Seq. I.D. No. 2 (comprising three cysteins) directly after synthesis shows the presence of a monomer without a ring formation via the cysteins. However, after dissolving the peptide (about 4 mg) in 1 ml water/DMF/DMSO (1:1:1;v:v:v) and leaving the solution overnight at room temperature, the peptide forms a ring via two cysteins and a dimer via the remaining free

10                   cystein. No higher polymers could be detected. When testing the binding activity of the two forms of the peptide to SDA, it became clear that the

dimer form of the peptide was much more active in binding SDAs than the non-dimer form.

5 Chemical analysis of the peptide by reduction, e.g. by mercaptoethanol or sodium borohydrid, destroyed the immunological activity completely, whereas oxidation, e.g. air or oxygen, restored the immunological activity.

**EXAMPLE 4:** Binding activity of Peptide Seq. I.D. No. 2 to samples from schizophrenic and non-schizophrenic individuals:

10 The binding activity of Peptide 14 (Seq. I.D. No. 2) to isolated PAAs was tested using the method described above. As seen in Fig. 1A, the above peptide positively bound seven out of eight PAAs obtained from different schizophrenic patients. Fig. 1B shows that the above peptide did not bind PAAs obtained from eight different  
15 non-schizophrenic individuals. Peptide Seq. I.D. No. 9 was used as a negative control.

The capability of Peptide 14 (Seq. I.D. No. 2) to bind SDA in plasma samples obtained from schizophrenic patients was then tested.  
20 As seen in Fig. 2A, this peptide positively bound four out of five SDA from different schizophrenic patients. Fig. 2B shows that the above peptide did not bind NSDA from fourteen out of fifteen different non-schizophrenic individuals. Peptide 14 (Seq. I.D. No. 9) was used as a negative control.

25

**Example 5:** Three dimensional structure:

The three-dimensional structure of the antigenic epitope of peptides according to the invention was predicted using a computerized program based on the mineral energy calculations.

30

As seen in Fig. 3, the predicted structure of the antigenic epitope is a cyclic structure comprising a hydrophobic core and an extension comprising about two positive charges. The positive charged extensions may be positioned in one of many possible spatial orientations.

(i) APPLICANT:

- APPLICANT:
- (A) NAME: YEDA RESEARCH AND DEVELOPMENT COMPANY LTD.
  - (B) STREET: THE WEIZMANN INSTITUTE OF SCIENCE
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  - (H) TELEFAX: +08 9470739

(ii) TITLE OF INVENTION: ASSAY FOR THE DIAGNOSIS OF SCHIZOPHRENIA  
BASED ON A NEW PEPTIDE

(iii) NUMBER OF SEQUENCES: 14

(iv) COMPUTER READABLE FORM:

- (A) MEDIUM TYPE: Floppy disk  
(B) COMPUTER: IBM PC compatible  
(C) OPERATING SYSTEM: PC-DOS/MS-DOS  
(D) SOFTWARE: PatentIn Release #1.0, Version #1.30 (EPO)

(2) INFORMATION FOR SEQ ID NO: 1:

(i) SEQUENCE CHARACTERISTICS:

- SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 28 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: unknown
  - (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 1:

Ser Gly Glu Thr Glu Asp Thr Phe Ile Ala Asp Leu Val Val Gly Leu  
1 5 10 15

Cys Thr Gly Gln Ile Lys Thr Gly Ala Pro Cys Arg  
20 25

(2) INFORMATION FOR SEQ ID NO: 2:

(i) SEQUENCE CHARACTERISTICS:

- SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 16 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: unknown
  - (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

---

(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 2:

Leu	Val	Val	Gly	Leu	Cys	Thr	Cys	Gln	Ile	Lys	Thr	Gly	Pro	Ala	Cys
1				5					10					15	

(2) INFORMATION FOR SEQ ID NO: 3:

- (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: unknown  
(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 3:

Ile	Ala	Asp	Leu	Val	Val	Gly	Leu	Cys	Thr	Gly	Gln	Ile	Lys	Thr	Gly
1				5					10					15	

Ala	Pro	Cys	Arg
			20

(2) INFORMATION FOR SEQ ID NO: 4:

- (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 19 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: unknown  
(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal



(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 4:

Ala Asp Leu Val Val Gly Leu Cys Thr Gly Gln Ile Lys Thr Gly Ala  
1                      5                      10                      15

---

Pro Cys Arg

(2) INFORMATION FOR SEQ ID NO: 5:

- (i) SEQUENCE CHARACTERISTICS:  
    (A) LENGTH: 18 amino acids  
    (B) TYPE: amino acid  
    (C) STRANDEDNESS: unknown  
    (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 5:

Asp Leu Val Val Gly Leu Cys Thr Gly Gln Ile Lys Thr Gly Ala Pro  
1                      5                      10                      15

Cys Arg

(2) INFORMATION FOR SEQ ID NO: 6:

- (i) SEQUENCE CHARACTERISTICS:  
    (A) LENGTH: 17 amino acids  
    (B) TYPE: amino acid  
    (C) STRANDEDNESS: unknown  
    (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 6:

Leu Val Val Gly Leu Cys Thr Gly Gln Ile Lys Thr Gly Ala Pro Cys  
1                      5                      10                      15

Arg

(2) INFORMATION FOR SEQ ID NO: 7:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 17 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: unknown
  - (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: peptide
- (iii) HYPOTHETICAL: NO
- (iv) ANTI-SENSE: NO
- (v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 7:

Leu Val Val Gly Leu Cys Thr Gly Gln Ile Lys Thr Gly Pro Ala Cys  
1                   5                   10                   15

Arg

(2) INFORMATION FOR SEQ ID NO: 8:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 17 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: unknown
  - (D) TOPOLOGY: unknown
- (ii) MOLECULE TYPE: peptide
- (iii) HYPOTHETICAL: NO
- (iv) ANTI-SENSE: NO
- (v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 8:

Leu Val Val Gly Leu Cys Thr Pro Gln Ile Lys Thr Gly Pro Ala Cys  
1                   5                   10                   15

Arg

(2) INFORMATION FOR SEQ ID NO: 9:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 20 amino acids

- (B) TYPE: amino acid
- (C) STRANDEDNESS: unknown
- (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

---

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 9:

Ser	Gly	Glu	Thr	Glu	Asp	Thr	Phe	Ile	Ala	Asp	Leu	Val	Val	Gly	Leu
1				5					10					15	

Cys	Thr	Gly	Gln
			20

(2) INFORMATION FOR SEQ ID NO: 10:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 16 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: unknown
  - (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 10:

Val	Val	Gly	Leu	Cys	Thr	Gly	Gln	Ile	Lys	Thr	Gly	Ala	Pro	Cys	Arg
1				5					10					15	

(2) INFORMATION FOR SEQ ID NO: 11:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 12 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: unknown
  - (D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 11:

Cys Thr Gly Gln Ile Lys Thr Gly Ala Pro Cys Arg  
1                      5                      10

(2) INFORMATION FOR SEQ ID NO: 12:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 16 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: unknown  
(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 12:

Leu Val Val Gly Leu Cys Thr Gly Gln Ile Lys Thr Gly Ala Pro Cys  
1                      5                      10                      15

(2) INFORMATION FOR SEQ ID NO: 13:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 15 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: unknown  
(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 13:

Leu Val Val Gly Leu Cys Thr Gly Gln Ile Lys Thr Gly Ala Pro  
1                      5                      10                      15

(2) INFORMATION FOR SEQ ID NO: 14:

- (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 16 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: unknown  
(D) TOPOLOGY: unknown
- 

- (ii) MOLECULE TYPE: peptide  
(iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: NO  
(v) FRAGMENT TYPE: internal

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 14:

Leu	Val	Val	Gly	Leu	Cys	Thr	Gly	Gln	Ile	Lys	Thr	Gly	Pro	Ala	Cys
1				5					10					15	

CLAIMS:

---

1. A peptide which binds antibodies that are found in elevated levels in body fluids of schizophrenic patients.
- 5 2. A peptide according to claim 1, which binds antibodies that are capable of specific binding to a peptide having the amino acid sequence of Seq. I.D. No. 2.
3. A peptide according to claim 1 or 2, which binds antibodies that are capable of binding to a peptide selected from the group, consisting  
10 of:
  - i. SGETEDTFIADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 1)
  - ii. LVVGLCTCQIKTGPAC (Seq. I.D. No. 2)
  - iii. IADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 3)
  - iv. ADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 4)
  - 15 v. DLVVGLCTGQIKTGAPCR (Seq. I.D. No. 5)
  - vi. LVVGLCTGQIKTGAPCR (Seq. I.D. No. 6)
  - vii. LVVGLCTGQIKTGPACR (Seq. I.D. No. 7)
  - viii. LVVGLCTPQIKTGPACR (Seq. I.D. No. 8)
4. A peptide according to any one of claims 1-3, capable of  
20 binding to antibodies which do not bind to peptides selected from the group consisting of:
  - i. SGETEDTFIADLVVGLCTGQ (Seq. I.D. No. 9)
  - ii. VVGLCTGQIKTGAPCR (Seq. I.D. No. 10)
  - 25 iii. CTGQIKTGAPCR (Seq. I.D. No. 11)
  - iv. LVVGLCTGQIKTGAPC (Seq. ID. No. 12)
  - v. LVVGLCTGQIKTGAP (Seq. ID No. 13)
  - vi. LVVGLCTGQIKTGPAC (Seq. ID No. 14)

5. A peptide according to any one of claims 1-4, comprising an amino acid sequence selected from the group, consisting of:

- i. SGETEDTFIADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 1)
- ii. LVVGLCTCQIKTGAC (Seq. I.D. No. 2)
- 5 iii. IADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 3)
- iv. ADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 4)
- v. DLVVGLCTGQIKTGAPCR (Seq. I.D. No. 5)
- vi. LVVGLCTGQIKTGAPCR (Seq. I.D. No. 6)
- vii. LVVGLCTGQIKTGAC (Seq. I.D. No. 7)
- 10 viii. LVVGLCTPQIKTGAC (Seq. I.D. No. 8).

6. A peptide according to any one of claims 1-4, selected from the group consisting of:

- i. SGETEDTFIADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 1)
- 15 ii. LVVGLCTCQIKTGAC (Seq. I.D. No. 2)
- iii. IADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 3)
- iv. ADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 4)
- v. DLVVGLCTGQIKTGAPCR (Seq. I.D. No. 5)
- vi. LVVGLCTGQIKTGAPCR (Seq. I.D. No. 6)
- 20 vii. LVVGLCTGQIKTGAC (Seq. I.D. No. 7)
- viii. LVVGLCTPQIKTGAC (Seq. I.D. No. 8)

7. A peptide which binds antibodies that are found in elevated levels in body fluids of schizophrenic patients, said peptide comprising at least one antigenic epitope, said epitope having a cyclic three dimensional structure consisting a hydrophobic core and a positively charged extension.

25

8. An assay for the diagnosis of schizophrenia in an individual,  
comprising the following steps:

- (a) obtaining a sample from said individual being a blood sample, a platelet-containing fraction thereof, or a fraction containing platelet-associated antibodies (PAA) shed from the platelets;
- (b) contacting said sample with a peptide capable of binding to antibodies that are found in elevated levels in body fluids of schizophrenic patients.
- (c) determining the level of binding of said peptide to said sample, a level higher than the binding level of said peptide to a sample from non-schizophrenic individuals indicating that said individual has a high likelihood of having schizophrenia.

9. An assay in accordance with claim 8, wherein the peptide of step (b) is a peptide having the amino acid sequence of Seq.ID.No.2

10. An assay in accordance with claim 8, wherein the peptide in step (b) comprises an a.a. sequence selected from the group consisting of:

- i. SGETEDTFIADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 1)
- ii. LVVGLCTCQIKTGPAC (Seq. I.D. No. 2)
- iii. IADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 3)
- iv. ADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 4)
- v. DLVVGLCTGQIKTGAPCR (Seq. I.D. No. 5)
- vi. LVVGLCTGQIKTGAPCR (Seq. I.D. No. 6)
- vii. LVVGLCTGQIKTGPACR (Seq. I.D. No. 7)
- viii. LVVGLCTPQIKTGPACR (Seq. I.D. No. 8).

11. An assay according to claim 8, wherein the peptide in step (b) is a peptide selected from the group consisting of:

- i. SGETEDTFIADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 1)
- ii. LVVGLCTCQIKTGPAC (Seq. I.D. No. 2)



- iii. IADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 3)
- iv. ADLVVGLCTGQIKTGAPCR (Seq. I.D. No. 4)
- v. DLVVGLCTGQIKTGAPCR (Seq. I.D. No. 5)
- vi. LVVGLCTGQIKTGAPCR (Seq. I.D. No. 6)
- 5 vii. LVVGLCTGQIKTGAPCR (Seq. I.D. No. 7)
- viii. LVVGLCTPQIKTGAPCR (Seq. I.D. No. 8)

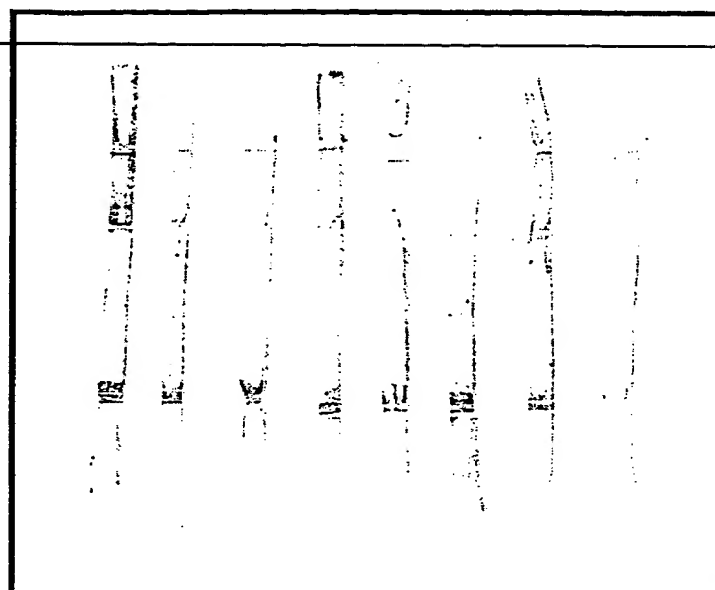
12. An assay in accordance with Claim 8, wherein the peptide in step (b) is a peptide in accordance with claim 7.

10 13. An assay in accordance with any of Claims 8-12, wherein said sample obtained from the individual is a whole blood sample.

14. A kit for use in the diagnosis of schizophrenia comprising:

- i. a support comprising one or more peptides in accordance with any one of claims 1-7 immobilized onto it;
- 15 ii. an anti-human immunoglobulin antibody or fragment thereof conjugated to a detectable marker;
- iii. reagents required for carrying out the assay, and;
- iv. instructions for use.

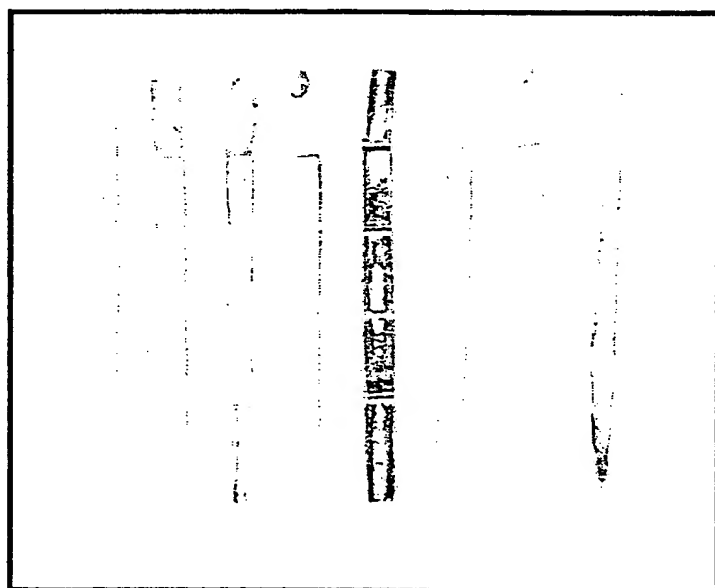
For the Applicants,  
**REINHOLD COHN AND PARTNERS**  
By: 



CONTROL

PEPTIDE 14

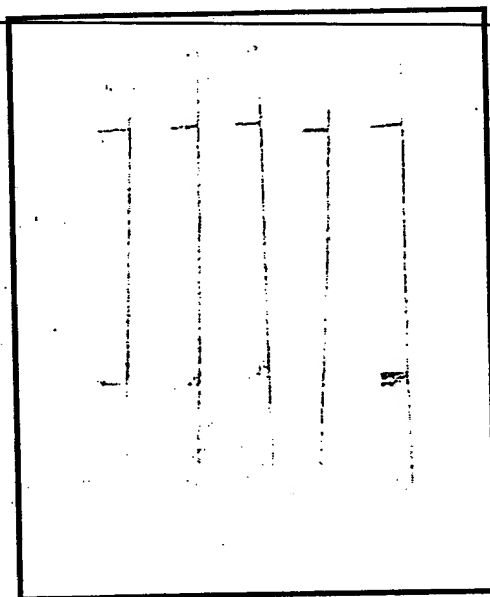
FIG. 1A



CONTROL

PEPTIDE 14

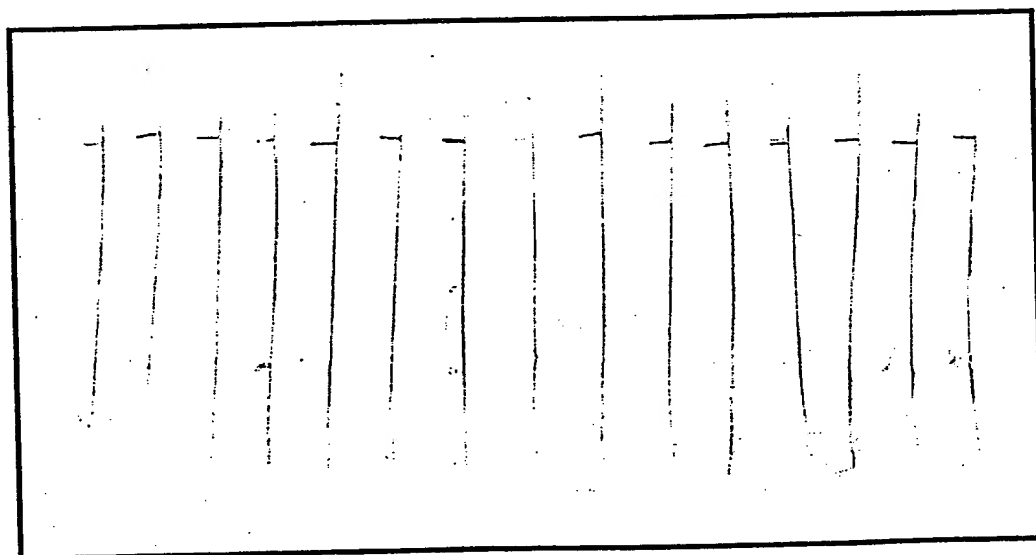
FIG. 1B



CONTROL

PEPTIDE 14

FIG.2A



CONTROL

PEPTIDE 14

FIG.2B

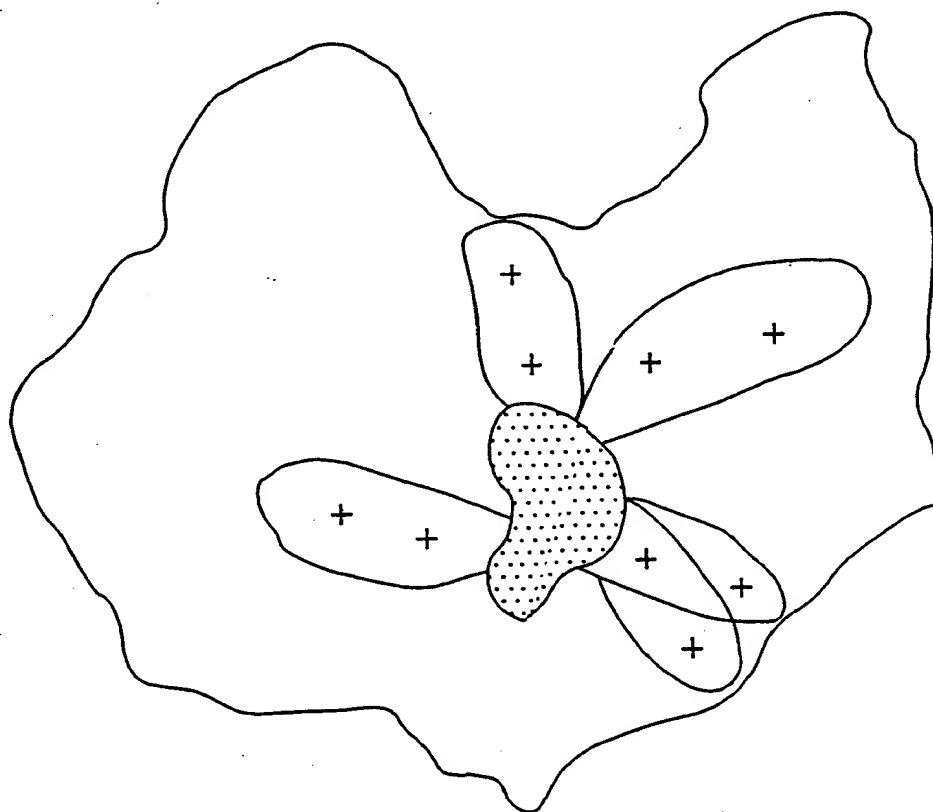


FIG. 3